JOURNAL
OF THE
WASHINGTON ACADEMY OF SCIENCES
VOL. IV JUNE 19, 1914 No. 12

PHYSICS.—*The optical character of the faint interference figure observed in high power objectives between crossed nicols.* FRED. EUGENE WRIGHT, Geophysical Laboratory.

To the petrologist the appearance, under crossed nicols, of a faint, apparently uniaxial interference figure in an objective of short focal length is a matter of common observation. It was at first considered to be the result of strain in the objective lenses but Rinne[1] in 1900 gave the correct explanation of the phenomenon and ascribed it to the rotation of the vibration plane of the transmitted plane-polarized waves at the steeply inclined lens surfaces. Rotation of this kind was noted by Fresnel[2] who deduced, in 1822, for plane-polarized waves transmitted through an isotropic plane parallel plate, the equation

$$\cot B = \cos^2 (i - r) \cdot \cot A, \qquad (1)$$

in which the angle of rotation B is expressed as a function of (a) the angle of incidence i, (b) the azimuth A of the plane of vibration of the incident plane-polarized light wave, and (c) the refractive index of the glass plate (contained in the expression $i - r$, r being the angle of refraction). This equation has been frequently verified by experiment and found to represent the observational data satisfactorily.

From Fresnel's equation it is evident that: (1) in case the vibration direction of the incident wave is parallel or normal to the plane of incidence ($A = 0°$ or $90°$) the vibration plane of the

[1] Centralblatt f. Miner. 1900, 88–89; see also C. Césaro, Bull. de l'Acad. Proy. de Belgique, Cl. d. Sci. 1906, 459; and F. E. Wright, Amer. J. Sci. (4), **31**: 187. 1911; Carnegie Inst. of Washington, Pub. **158**: 74–76. 1911.

[2] Oeuvres, **1**: 441–799.

incident wave is not rotated on transmission ($B = 0$); (2) for a given angle of incidence i the maximum rotation is obtained when the wave front normal is included in the diagonal plane between the principal planes of the crossed nicols (azimuth angle $A = 45°$); (3) the angle of rotation increases with the angle of incidence i.

Now a spherical surface may be considered to consist of a series of minute planes inclined at all angles with the vertical and in all azimuths. The rotatory effect of such a surface on transmitted plane-polarized light waves is, therefore, different in different directions, the result being a distinct uniaxial cross with quadrants whose intensity of illumination increases with the distance from the center. This is, in brief, the explanation of the faint uniaxial cross which appears in all high power objectives between cross nicols. The plane polarized light waves whose normals are parallel to the principal planes of the nicols suffer no rotation, while all others are rotated to an increasing extent as their azimuth A increases until the maximum rotation at 45° is reached. The reasons why these phenomena are so much more distinct in high power than in low power objectives are, (1) the larger numerical aperture of high power objectives and (2) the fact that in such objectives the front lens of the system is a small uncorrected glass hemisphere at whose steeply inclined sides the transmitted light waves are rotated through relatively large angles.

If now a sensitive tint plate be inserted along the $NW-SE$ diagonal, between crossed nicols either below the condenser or above the objective the quadrants of the faint interference cross, observed in the upper focal plane of the objective, appear differently colored, the northeast and southwest quadrants being blue-green and the remaining two quadrants orange yellow, or vice versa if the sensitive tint plate be inserted along the $NE-SW$ diagonal. The arms of the interference cross assume the color of the sensitive tint plate irrespective of the direction along which it is inserted. These interference colors appear much more distinct when the sensitive tint plate is inserted so that its vibration directions include only a small angle (1° to 10° depending on the intensity of illumination) with the principal nicol planes.

This distribution of colors in the interference figure on insertion of the sensitive tint plate is precisely that observed on a weakly birefracting, optically positive, uniaxial mineral under similar conditions and would lead one to infer that the objective is uniaxial and optically positive in character. All high power objectives show this behavior and it is of interest to inquire into the cause of the conversion of an isotrophic substance, like glass, into an apparently uniaxial, optically positive substance. The problem can be solved both by experiment and by theoretical computation.

Experiment 1. Remove from the petrographic microscope the condenser, objective and eye piece and place a sensitive tint plate between the crossed nicols so that one of its vibration directions includes only a small angle (+2°) with the principal plane of the polarizer. Turn the analyzer through a small angle (+4°) clockwise and note that the interference color changes from the sensitive tint to a greenish hue; if now the analyzer be rotated counterclockwise to −2° the hue changes from green through the sensitive purple tint to a magenta. Further rotation of either the sensitive tint plate or the analyzer through large angles increases the illumination of the field to such an extent that the faint differences in color hue are practically masked and cannot be readily detected.

Experiment 2. Prepare fine glass beads, 0.1 to 0.5 mm. in diameter, by fusing the end of a fine glass thread in a small Bunsen flame. observe the beads under a low power objective between crossed nicols and note that interference phenomena, similar to those recorded above in the high power objective, appear when the sensitive tint plate is inserted in the different positions, especially when its vibration directions include only a small angle with the principal nicol planes. The same statement holds true for small air bubbles in Canada balsam or glycerine.

Experiment 3. Observe that on the outer margins of the glass beads of experiment 2 the color phenomena are reversed, a narrow blue-green fringe appears as a frame about the orange yellow quadrants and an orange yellow line on the periphery of the blue green quadrants. The same phenomena are clearly shown on the air bubbles in Canada balsam and glycerine. If the optical character were judged by these outlying colors alone, it would be uniaxial negative. The air bubbles and glass beads appear, in short, to be optically positive in the center and optically negative at the margins.

Experiment 4. Place small drops (0.5 to 1 mm. in diameter) of mercury on an object glass under a low power objective. Raise the condenser, so that steeply inclined rays are reflected from the equatorial zone of the upper half of the mercury drops. Observe that only the outer margin of each drop is illuminated and that the in-

tensity of illumination is not uniform, the circular field being divided into four quadrants, the dark dividing lines corresponding to the zero isogyres of the interference figure. On insertion of the sensitive tint plate these quadrants become brightly colored, two opposite quadrants in blue green tones and the other two in orange yellow tones. The colors are remarkably brilliant and correspond in their distribution to that of a uniaxial optically negative mineral. If monochromatic light be used the angular rotation for each part of the field can be determined by rotating the upper nicol and testing the position of extinction by means of the bi-quartz-wedge plate and then, by use of Fresnel's equation for the rotation of plane-polarized light waves on reflection, the refractive index of the mercury can be computed for the particular wave length of light employed.

Experiment 5. Cement to the two sides of a small 45° total reflecting prism two strips of plane-parallel glass (carefully selected cover glass strips serve the purpose well) so that the ends of the glass strips extend 6 or 8 mm. beyond the edge of the prism. Drill a hole transversely through a brass cylinder and insert a brass rod in the same. Lacquer the inside of the brass cylinder with a matt black. Cement the hypothenuse face of the prism to this rod, so that the prism edge is at right angles to the axis of rotation of the rod (fig. 1). If now the axis of rotation be placed parallel with one of the principal nicol planes, the two glass plates can be rotated and in every position the angle of incidence i for both plates is the same while the azimuth angles A are of opposite sign.

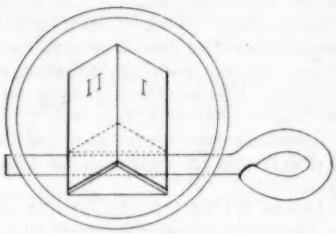

Fig. 1

The effect of this arrangement is analogous to that of a half shade apparatus, namely, that, if in the one quadrant the angle of rotation of the transmitted plane-polarized waves is $+A°$, it is $-A°$ in the adjacent quadrant. If now the sensitive tint plate be placed between the crossed nicols, the color phenomena described in the preceding experiments appear clearly marked; by rotating the prism all gradations between the undisturbed sensitive tint purple to bright green in the first quadrant and yellow in the second can be obtained. This experiment illustrates clearly the principle underlying the interference phenomena observed in the lenses of a high power objective.

Experiment 6. Since the amount of rotation of refracted or reflected light waves at inclined surfaces of an anisotropic substance depends on the difference in refractive index between the substance and the surrounding medium, it is proper to infer that, in case a glass bead be immersed in a liquid of the same refractive index, no rotation will occur and hence no color phenomena will be observed. This is approximately correct, though in many instances the color phenomena

are far more distinct under such conditions than one might expect and the question arises as to the refractive index of the surface film of the glass bead. Such a film is under the influence of surface tension forces and hence is exposed to a different set of mechanical forces than that which obtains inside the bead. It is, therefore, natural that its refractive index (expression of influence of original system of forces on light wave system of forces) should be different. To test this conclusion still further a mixture of alcohol and ether on the one hand was prepared and a second mixture of water and glycerine. Now these mixtures have the same refractive index for sodium light, the same density and approximately the same dispersion. On shaking the two together the alcohol and ether form small drops suspended in the water-glycerine mixture and furnish, therefore, an excellent system for testing the idea that the refractivity index of the surface film may be different from that inside the drops. Although experiments along this line are still in progress it may be stated that the evidence so far obtained is not sufficiently definite to warrant definite statements.

The above experiments prove conclusively that the apparent optically positive character for transmitted plane polarized light rays and optically negative character for reflected rays when tested by means of the sensitive tint plate, is due to rotation of the plane of vibration at the steeply inclined surfaces of the isotropic substance. In passing from one isotropic substance to a second the direction of vibration remains, of course, in the same plane but the azimuth of the plane of vibration changes (suffers rotation) because of the change of direction of the ray (wave normal) on refraction.[3]

The phenomena exhibited by the objective on insertion of the sensitive tint plate can also be deduced by computation from the standard Fresnel formulas. The angle of rotation of the plane of vibration for any plane-polarized wave entering a plane surface of an isotropic substance of refractive index n at an angle of incidence i and an azimuth angle E is given by the equations

$$\sin i = n \sin r,$$
$$\cot B = \cos (i - r) . \cot A.$$

For a ray transmitted through a plate, equation 1 is valid. But ordinary white light consists of light of all wave lengths throughout the visible spectrum and the angle of rotation varies slightly with the change in wave length but it is so slight that for the pres-

[3] For a more complete discussion of these phenomena, see Carnegie Institution of Washington, Pub. **158**: 75–79. 1911.

ent purposes it may be neglected. Having given the angle of rotation B of the plane of vibration the problem resolves itself practically into a determination of the intensity of illumination for the different parts of the visible spectrum for different relative positions of the sensitive tint plate and the analyzer, the resulting color being the integral result of the distribution of color intensity over the entire visible spectrum.

For this purpose the standard Fresnel intensity equation

$$I = \cos^2 \varphi + \sin 2(\varphi - \vartheta) \sin 2\vartheta \cdot \sin^2 \pi \cdot \frac{d(\gamma' - \alpha')}{\lambda} \qquad (2)$$

is applicable, in which I is the percentage intensity of illumination, φ, the angle included between the two nicols, ϑ, the angle which the vibration direction γ of the sensitive tint plate includes with the principal plane of the analyzer, d the thickness of the sensitive quartz plate used, $\gamma' - \alpha'$, the birefringence of the quartz sensitive tint plate for the particular wave length λ of light employed. The results of computation by this equation of the intensity of the transmitted light for different angles φ and ϑ, and wave lengths λ for a quartz plate 0.03 mm. thick (thickness for the sensitive tint whereby the path difference for $\lambda = 550\mu\mu$ is half a wave length and $\sin^2 \frac{d(\gamma' - \alpha')}{\lambda} = 1$) cut parallel to the principal axis are listed in Table 1 and presented graphically in figure 2.

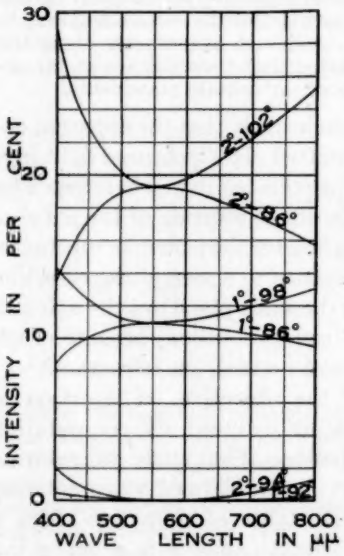

Fig. 2. The curves of this figure represent graphically the data of Table 1, namely, the intensity of the light, in per cent, for different wave lenths λ after transmission through the polarizer, sensitive tint quartz plate (0.03 mm. thick cut parallel to the optic axis which makes an angle ϑ with the vibration plane of the polarizer) and the analyzer whose principal plane includes an angle ϕ with that of the polarizer.

TABLE 1

λ IN μμ	$\gamma' - \alpha'$	INTENSITY IN PER CENT $\vartheta = +1°$			INTENSITY IN PER CENT $\vartheta = +2°$		
		$\varphi = 86°$	92°	98°	$\varphi = 86°$	94°	102°
	0.00						
400	954	8.56	0.48	14.23	13.70	1.91	28.71
450	936	10.06	0.18	12.14	17.29	0.70	22.80
500	925	10.75	0.04	11.17	18.95	0.15	20.07
550	917	10.93	0.00	10.93	19.37	0.00	19.37
600	909	10.81	0.03	11.10	19.08	0.10	19.86
650	902	10.52	0.08	11.50	18.39	0.33	20.99
700	898	10.17	0.15	11.99	19.55	0.58	22.37
750	894	9.79	0.23	12.51	16.65	0.92	23.85
800	892	9.63	0.30	13.02	15.79	1.21	25.27

Table showing percentage intensity of transmitted light for different wave lengths λ after passing through polarizer, sensitive tint quartz plate (0.03 mm. thick and cut parallel to the principal axis, and including an angle ϑ with the principal plane of the polarizer) and the analyzer whose principal plane includes an angle φ with that of the polarizer.

Extended comment on this table and figure is unnecessary. From both it is evident that for $\vartheta = +1°$, the intensity of the transmitted light is not the same throughout the visible spectrum for a given angle φ between the nicols; thus for $\vartheta = +1°$ and $\varphi = 86°$, the intensity of illumination is greatest in the middle or green part of the spectrum about $550\mu\mu$ and the resultant color is of a greenish hue, while for $\vartheta = +1°$ and $\varphi = 98°$, the intensity of illumination for the central part of the spectrum is at a minimum and the resulting hue is of the nature of a minus green which is magenta. Similar relations obtain for the angle $\vartheta = +2°$. For still larger angles ϑ, the intensity of illumination throughout the spectrum is so great that the slight differences in percentage intensity for different wave lengths are not sufficient to dominate the hue of the total light transmitted. It is only when the average intensity of illumination throughout the entire spectrum is so slight that it approaches the limit of threshold vision and perception of color differences that the color intensity differences are most marked.

From equation 2 we find by forming the first and second differential quotients after φ, that for a given ϑ the intensity of illumination is a minimum when $\varphi = 90° + \vartheta$. This is also evident from figure 1 in which the relations appear so clearly marked that their application to the case of a system of the steeply inclined lens surfaces in a high power objective involves no difficulty except that of tedious computation in following each ray through the lens system. Such a computation is, moreover, unnecessary because we know the approximate inclinations of the different lens surfaces for the different parts of the field, and can estimate the approximate rotation of the plane of vibration of the transmitted light wave, and can deduce therefrom the resultant color. The results of such an estimation agree well with those of observation. It seems, however, unnecessary to present the details of this part of the solution of the problem as no new principle is involved and the final result can be inferred at once by analogy from the results already given.

From the foregoing it is evident that, in weakly birefracting minerals, the color phenomena produced in the objective alone on insertion of the sensitive tint plate tend to veil and to render uncertain, to a greater or less extent, the interference colors due to the mineral plate under observation; special care should be taken in such instances to test by other methods any inference regarding the optical character of the mineral under test.

It is also evident that the rotation, by the lens system, of the plane of vibration of transmitted light waves has an effect on the measurement of the optic axial angle of a crystal plate but this effect is usually not sufficiently large to interfere seriously with the accuracy of the results obtained, which at best are not of a high order of precision because of a number of factors which enter into the problem and over which the observer has little control.[4] These have been discussed elsewhere by the writer and need not be repeated here. Suffice it to state that the weak uniaxial interference cross observed between crossed nicols in high power objectives is inevitable and also the apparent optically positive

[4] Carnegie Inst. of Washington, Pub. **158**: 147–200. 1911.

character of the interference figure when tested in the usual manner by the insertion of a sensitive tint plate either above the objective or below the condenser.

PHYSICS.—*A new half shade apparatus with variable sensibility.* FRED. EUGENE WRIGHT, Geophysical Laboratory.

The importance of variable sensibility in half shade apparatus to meet best the different conditions of illumination and observation has been frequently emphasized in recent years and several instruments have been constructed which serve the purpose more or less satisfactorily. The device described in the following paragraphs is a simple, inexpensive half shade apparatus which accomplishes its object well and merits a brief word of description. It is essentially the instrument used in experiment 5 of the preceding article in which the theory underlying its construction is outlined briefly. The essential elements of this theory are: (1) a plane-parallel glass plate of refractive index n (tilted so that it makes an angle i with the line of propagation of an incident plane-polarized light wave, and also so that the normal to the plane of incidence includes an azimuth angle A with the line of vibration of the light wave), rotates the plane of vibration of the transmitted light wave through an angle B which can be computed from the Fresnel equation, $\cot B = \cos^2 (i - r) \cdot \cot A$; both experiment and theory prove that the angle of rotation increases with the refractive index n of the substance and with the angle of incidence i; also with the azimuth angle A up to 45°; when A = 0°, 90°, 180°, the rotation is nil. For a given angle i the rotation angle is a maximum for A = 45°. If, therefore, a plane-parallel glass plate be mounted so that it can be rotated about a horizontal axis in the first (*NE*) quadrant midway between the principal nicol planes, the azimuth angle A for incident waves from the polarizer is 45° for all angles of incidence i and the angle of rotation of the transmitted waves can be calculated from the simplified Fresnel equation, $\cot B = \cos^2 (i - r)$. If now a second glass plate be taken and rotated about an axis in the second (*NW*) quadrant, the azimuth angle of the incident light waves from the polarizer is –45° and the Fresnel equation re-

duces to $\cot B = -\cos^2(i-r)$. For a given angle of incidence the angle of rotation produced by the glass plate in the second quadrant is accordingly equal in value to that in the first quadrant but opposite in sign. Thus in a glass plate of refractive index 1.615 the angle of rotation of the plane of vibration of plane polarized waves incident at 40° under an azmuth angle 45° is 1°57′ while the rotation angle in a second plate for the same light wave incident at 40° under an azimuth angle −45° is −1° 57′ (fig. 1). If now two glass plates be so mounted that they meet in a fine line they form a half shade apparatus of a definite angle of rotation. On varying the angle of incidence i by rotating the system, we can change the rotation angle B and thereby introduce the principle of variable sensibility into our system.

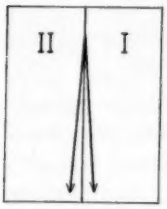

Fig. 1

Although there are a number of methods possible for rotating the two glass plates simultaneously, the simplest method which has occurred to the writer is illustrated by figure 2. Into a brass cylinder (telescope or microscope tube) a diametral hole is bored transverse to the axis and into this a rod is fitted so that it can be rotated about its axis. Two plane-parallel thin plates are mounted on the sides of a small right angled total-reflecting prism so that their ends project beyond the prism any desired amount depending on the size of field to be covered. The edges of these plates are beveled at 45° and the ridge is cemented with Canada balsam, thus producing a fine division line between the two glass plates. In case plane-parallel polished glass plates are not available thin cover glass plates may be selected and serve the purpose satisfactorily. The glass prism is then cemented to the rotating bar in the tube as

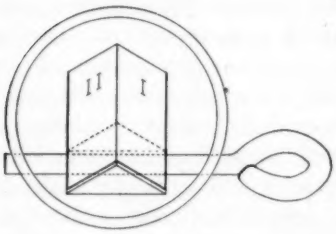

Fig. 2

indicated in figure 2, care being taken to have the prism edge perpendicular to the axis of rotation.

The axis of rotation is placed in an $E - W$ position parallel to one of the principal nicol planes. In this position the glass plates make equal and opposite angles with the $N - S$ principal nicol plane; the angles of rotation for the different angles of tilting are equal and of opposite sign and are listed in Table 1 (computed by the Fresnel equation), and are represented graphically in figure 3.

TABLE 1

Table showing angular rotation of plane of vibration of light wave transmitted through half shade apparatus for different angles of rotation about horizontal axis. The values of the angular rotation are listed for the adjacent quadrants (glass plate I and glass plate II, fig. 2) both for a single glass plate and also for two superimposed glass plates of refractive index $n = 1.515$ and $n = 1.920$.

ANGLE OF ROTATION	$n = 1.515$				$n = 1.920$			
	SINGLE PLATE		TWO PLATES		SINGLE PLATE		TWO PLATES	
	Quadrant I	Quadrant II	Quadrant I	Quadrant II	Quadrant I	Quadrant II	Quadrant I	Quadrant II
0°	0°00′	0°00′	0°00′	0°00′	0°00′	0°00′	0°00′	0°00′
5	0 29	−0 29	1 00	−1 00	0 56	−0 56	2 03	−2 03
10	0 58	−0 58	2 01	−2 01	1 53	−1 53	4 07	−4 07
15	1 29	−1 29	3 05	−3 05	2 52	−2 52	6 12	−6 12
20	2 01	−2 01	4 11	−4 11	3 53	−3 53	8 21	−8 21
25	2 35	−2 35	5 22	−5 22	4 57	−4 57	10 36	−10 36
30	3 12	−3 12	6 37	−6 37	6 02	−6 02	12 48	−12 48
35	3 53	−3 53	8 01	−8 01	7 17	−7 17	15 08	−15 08
40	4 39	−4 39	9 32	−9 32	8 35	−8 35	17 31	−17 31
45	5 40	−5 40	11 31	−11 31	10 03	−10 03	20 04	−20 04
50	6 30	−6 30	13 03	−13 03	11 33	−11 33	22 29	−22 29
55	7 37	−7 37	15 05	−15 05	13 14	−13 14	25 02	−25 02
60	8 54	−8 54	17 21	−17 21	15 06	−15 06	27 36	−27 36
65	10 22	−10 22	19 48	−19 48	17 08	−17 08	30 06	−30 06
70	12 03	−12 03	22 29	−22 29	19 18	−19 18	32 31	−32 31
75	13 58	−13 58	25 18	−25 18	21 41	−21 41	34 50	−34 50
80	16 03	−16 03	28 10	−28 10	22 09	−22 09	36 58	−36 58
85	18 40	−18 40	31 16	−31 16	26 58	−26 58	39 00	−39 00

The values given in Table 1 are the angles computed from Fresnel's equation above. The actual situation is a little more

complex than one might infer from the equation alone, because of internal reflections and surface film effects but the values listed in Table 1 indicate the order of magnitude of the angular rotation of the vibration plane of a plane-polarized light wave for different angles of inclination of the half shade apparatus. Since the effects of such factors, as internal reflection and surface films, affect both glass plates equally, they do not appreciably disturb the sensitiveness of the apparatus. The values are listed for angles of rotation of the apparatus up to 85°; in actual practice, however, rotation angles above 60° are not used and hence are not represented in figure 3.

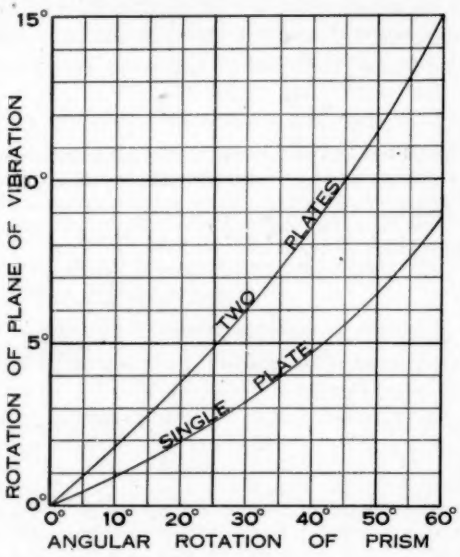

Fig. 3. Curves showing angular rotation of the plane of vibration of a beam of plane-polarized light on passage through glass plates of half shade device for different angles of rotation of apparatus about horizontal axis.

Instead of rotating the apparatus through large angles, it is simpler and better to mount two superimposed plane-parallel glass plates to each side of the right angled prism. The angles of rotation with this arrangement are listed in Table 1.

With this apparatus, which is applicable both to white and to monochromatic light, the half shade principle with variable sensibility is attained. In petrographic microscope work extinction angles can be measured by its use, when it is placed in the lower

focal plane of the positive eye piece, with an accuracy nearly equal to that of the writer's bi-quartz wedge plate.[1]

The bi-quartz wedge plate is, however, superior to the present device because its action is independent of the direction of the line of junction between the two halves of the plate. The adjustment of the tilting glass plates is, however, not difficult between crossed nicols and this form of half shade apparatus has the advantage of slight cost and ease of preparation, it being possible to construct the complete apparatus in two or three hours time. The differences in angle of rotation for different wave lengths for a definite position of the apparatus are small and practically negligible for most work, the result being, that even for large angles of tilting of the apparatus, the field remains uncolored and of a light gray hue. In this respect it differs from the bi-quartz wedge plate and for certain purposes may be superior to it.

PHYSICS.—*A transmission and reflection photometer for small areas.* P. G. NUTTING and L. A. JONES. (Communication No. 15 from the Research Laboratory of the Eastman Kodak Company.)

In many optical investigations it is desirable to measure the brightness of small areas—1 mm. square or less. The instrument here described was devised to measure the brightness of optical images, the local densities in photographic negatives, and the reflecting powers of different parts of photographic prints and other pictures. It has proved exceedingly convenient and precise, and so nearly all that may be hoped for in this type of photometer that a description may be of general interest.

The chief advantages secured in our instrument are the following:

1. The elimination of errors due to fluctuation in the comparison source by using the same source for comparison light and for the source of transmitted or reflected light.

[1] F. E. Wright, Am. J. Sci. (4), **26**: 377–378. 1908. Carnegie Inst. of Washington, Pub. **158**: 139. 1911; see also M. Berek, Neues Jahrbuch f. Mineral., B. B., **33**: 583–661. 1912.

2. The elimination of corrections for shift of zero by providing easy means of balancing the two beams with an open system.

3. A direct view of the object sighted upon at all times during measurement. This is obtained by focusing an image of that object at the dividing line of the photometer cube.

4. An open linear scale, reading directly from zero to 100 per cent provided by a rotating comparison beam and stationary sector. The photometer head used is, in fact, that of the Bechstein illuminometer. The ease and rapidity of setting provided by this means of varying the comparison beam are known to all who have used it.

A plan of the optical parts of the photometer is shown in the figure as used for determining transmissions.

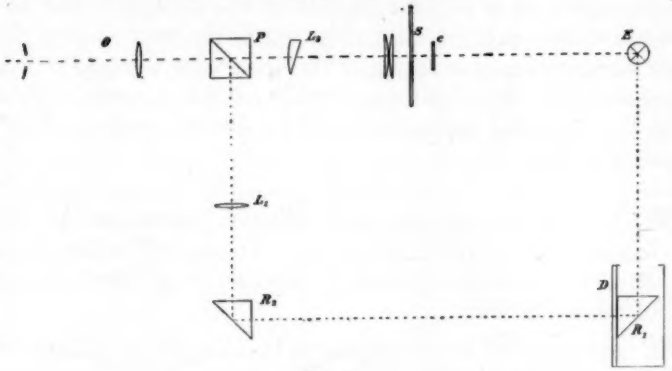

Fig. 1.

The source of light E is a condensed filament, 100-watt tungsten lamp run on the lighting circuit. Light from this illuminates the comparison screen c of thin, solid opal glass. This screen is viewed through the ocular O, the photometer cube P, the rotating excentric lens L_2, and stationary sector S. Light from E also passes to the photometer cube through the path ER_1R_2P. R_1 is a reflecting prism within a metal box mounted on a stand. The front face of this box is a plate of flashed opal glass D, serving as a secondary source by diffusing the light. The plate whose transmission is to be determined is placed directly in front of this diffusing screen, thus eliminating errors due to diffusion in the transmission measured. An image of the plate to be observed is thrown on the photometer cube P, by means of the lens L_1, and the reflecting prism R_2. These

latter pieces are mounted on an arm carried by the instrument itself, the lens L_1 being adjustable in position.

In use, the sector S is first set to read 100 and the source E moved toward or away from C until a balance is secured without the plate to be measured. The instrument will then read percentage transmission from nothing to 100 per cent directly, with but a very slight zero correction.

For determining reflecting powers, R_1 and D are not used and R_2 is rotated to face downward (instead of horizontally, as shown). The surface upon which observations are to be taken is placed directly under R_2 on the table and the lens L_1 focussed upon the surface which is illuminated directly by the source E at an angle of about 45°. Ordinarily, it is diffuse reflecting power that is desired, and the surface is placed horizontal—specularly reflected light not entering the instrument.

The zero adjustments for measuring reflecting powers are similar to those made in measuring transmissions. If only relative values are desired, as in measuring up a photographic print, clear paper is placed in the field, the sector set to read 100 per cent and the source E adjusted to give a match at the cube. If actual reflecting powers are desired, a mat surface, say a block of magnesium carbonate, whose reflecting power has been determined on an absolute reflectometer,[1] is placed in position, the sector S to read its absolute reflecting power, and the source E adjusted as before. The instrument will then give directly the diffuse reflecting power of any other surface placed in the field. If specular reflecting power is to be determined, total reflecting power is measured on the absolute instrument and diffuse reflecting power measured as just described.

The instrument, as a whole, is easily, quickly, and permanently adjustable; readings may be taken with it as rapidly and accurately as with any kind of visual photometer, and we have not yet detected any systematic errors in its readings. For months it has been in constant use by a number of observers in the sensitometry of photographic plates and papers. With a magnifying ocular it has even been used as a microphotometer of low power.

[1] P. G. Nutting, Journ. Wash. Acad. Sci. **2**: 505. December 19, 1912.

CHEMISTRY.—*The iodine number of linseed and petroleum oils.*[1] W. H. SMITH and J. B. TUTTLE, Bureau of Standards. Communicated by G. K. Burgess.

The iodine number of linseed and petroleum oils was determined according to the Hanus method. Each of the three factors, weight of sample, time of absorption, and amount of Hanus solution, was studied for a series of burnt linseed oils and petroleum oils. Variations of weight of the raw linseed oil shows that a constant volume is obtained for weights of the oil up to 0.25 gram. Beyond this value the iodine number decreases with increasing weight. For burnt linseed oils the range of weight over which the iodine value is constant decreases with increased burning of the oil. Petroleum oils on the contrary approach a constant value when 0.6 gram or more of the sample is taken. Varying the time of absorption from five to sixty minutes shows that the reaction approaches a maximum in about ten minutes. Thereafter absorption is slow, and a few minutes one way or another has little effect on the value obtained. When the amount of Hanus solution is varied from 20 to 75 cc the results indicate that the oil with the highest iodine number does not require the greatest excess of iodine to reach maximum absorption value. The effect of temperature on the value obtained is more marked for burnt linseed oils than for boiled or raw oils. The results as a whole indicate that concordance is obtained only when a prescribed procedure is followed with exactness. To obtain comparable results a standard procedure should be followed in which the limits are strictly defined. This is particularly true of burnt linseed oils.

CHEMICAL TECHNOLOGY.—*The determination of ammonia in illuminating gas.*[2] J. D. EDWARDS, Bureau of Standards. Communicated by G. K. Burgess.

The method generally used for the determination of ammonia in purified illuminating gas depends upon the absorption of the ammonia in a standard acid solution, the amount of ammonia absorbed from a measured volume of gas being determined either by

[1] To appear in full as Bureau of Standards Technologic Paper No. 37.

[2] To appear in full as Bureau of Standards Technologic Paper No. 34 (in press).

titration of the acid remaining unneutralized or less frequently by allowing gas to pass until a change is shown by the indicator used.

The choice of the proper indicator to use for this determination is of greater importance than the choice of apparatus. The indicators which were found to be most suitable for the determination of ammonia in gas were sodium alizarinsulphonate, cochineal, and paranitrophenol. The presence of glass beads which are used in some of the absorption apparatus may lead to erroneous results for two reasons: First, the beads may yield alkali on contact with the absorbing liquid; second, washing of the beads may be incomplete. It is recommended that the operator test the solubility of any beads he may use; the method of washing out the apparatus should also be tested.

Five different forms of apparatus were tested: The Referees apparatus, the Emmerling tower, the Lacy apparatus, the common form of gas wash bottle, and a modified form of the Cumming gas bottle. The relative efficiency, and from this the probable accuracy, of the different forms of apparatus was determined by running them in parallel, using gas from a common supply. As a result of this comparison it was found that the Emmerling tower gave results which were somewhat higher than those obtained with the other forms and that the wash bottle gave results consistently lower. With careful operation any one of the five forms of apparatus tested would ordinarily give results that are well within the limits of accuracy required for this determination, either for commercial control work or for the purpose of gas inspection.

PHYSICAL CHEMISTRY.—*The influence of atmospheric conditions in the testing of sugars.*[1] F. J. BATES and F. P. PHELPS. Communicated by G. K. Burgess.

A simplified form of Marvin's evaporation equation has been applied to the evaporation of raw sugar solution during filtration. Marvin's formula reduces to $\frac{dQ}{dt} = C\ (P_s - P_a)$ or $Q = C\ (P_s - P_a)\ T$, which, it is shown, fits the observations satisfactorily. Q = the change due to evaporation in the time T, P_s = the vapor pressure of the sugar solution, P_a = the saturation vapor pressure in the air at the temperature of the dew point.

[1] To appear in full as Bureau of Standards Scientific Paper 221 (in press).

The constant, C, has been determined for a number of different cases: (1) When the solution is poured back upon the filter after all has run through; (2) when it is poured back after about one-half has run through; (3) when it is not poured back at all. Observations were made by two methods: First, by weighing the solution at intervals during the filtration; second, by observing the change in polarization. In the polarization method one tube was filled, as a reference tube, with solution that had been covered during filtration, since filtration could not be avoided. It is shown, however, by weighing, that the evaporation in this case is quite negligible. Other tubes were filled with solution which had not been covered during filtration. The difference in polarization between these tubes and the reference tube is the change due to evaporation. This was done under various atmospheric conditions.

The observations were made in a thermostated room where the amount of moisture present in the air, as well as the temperature, could be varied at will, the range of adjustment being $(P_s - P_a) = 4$ mm. of Hg to $(P_s - P_a) = 41$ mm. of Hg. In practice $P_s - P_a$ rarely exceeds 22 mm.

It was found that in the case where the solution was not poured back upon the filter the change in polarization due to evaporation is so small as to be quite negligible in ordinary sugar testing. The change is represented by $Q = 0.00017\ (P_s - P_a)\ T$. However, in case a portion of the solution is poured back, the change due to evaporation is not negligible in ordinary testing but must either be prevented, by covering the funnel, or corrected for by the equation $Q = 0.0006\ (P_s - P_a)\ T$.

CRYSTALLOGRAPHY.—*The crystallographic and optic properties of magnesium and manganese pyrophosphates.* OLAF ANDERSEN, Geophysical Laboratory. Communicated by Fred. E. Wright.

Crystals of magnesium and manganese pyrophosphates were obtained by melting the substances[1] and cooling the melts.

[1] The pyrophosphates were produced by heating magnesium (or manganese) ammonium orthophosphate. The thermal examination of these and other substances is dealt with in a different paper. $Mg_2P_2O_7$ melts at 1383°C., $Mn_2P_2O_7$ at 1196°C.

Complete crystallization always resulted, no matter how quickly the cooling took place and from the cavities some measurable crystals could be picked out.

MAGNESIUM PYROPHOSPHATE

The magnesium pyrophosphate ($Mg_2P_2O_7$) forms tabular crystals of variable size, the tables generally having an orientation perpendicular to the surface of the melt and roughly parallel to each other or radiating from a few centers near the sides of the crucible. The measurable crystals were of the average size 3 x 2 x 1 mm. They were, however, always formed by parallel (or subparallel) intergrowths of a number of small individuals and the signals reflected from the faces of such crystals were multiple and indistinct. Fairly sharp signals could be obtained by stopping off the light from all the subfaces except the two joining in the little edge selected for measurement. In this way one crystal often yielded a number of measurable edges between the same two faces. The two circle goniometer (Goldschmidt's) was accordingly used as a one circle instrument.

The crystals proved to be monoclinic belonging to the prismatic class. From the average of the measurements the axial ratios were calculated as follows: $a : b : c = 0.7947 : 1 : 1.0880$; $\beta = 75°49'$. Referred to these axial ratios the following forms were observed: c (001); z (110); r ($\bar{1}01$); x ($\bar{1}12$).

The results of the measurements are listed in Table 1 containing the values obtained from 14 crystals, some of which gave only one measurable edge, while from others several edges for each pair of faces were obtained.

Figure 1 reproduces the general shape of a composite crystal. The predominating forms are always c and z, the crystals being tabular parallel to c or sometimes short prismatic along z, while the other two forms r and x only occur as narrow truncations of the edges; r, however, is sometimes broad enough to give fairly good signals. The prism z is not observed except as bright and smooth cleavage faces. The other forms occur as natural crystal faces always fairly bright and without striation.

The subindividuals of the larger crystals are arranged so as to make the bases form steps descending in the direction of the

negative a-axis. By this arrangement the composite crystals often approximate an orthorhombic shape. Sometimes the crystals are grown together in a way indicative of polysynthetic twinning. No definite twinning law however could be inferred from these intergrowths. The crystals are colorless and of a glassy luster. The hardness is a little less than 4. Cleavage perfect after the faces of the prism z and also good parallel to c. Density determinations with pycnometer gave $G(\frac{25}{4}) = 3.058$.[2]

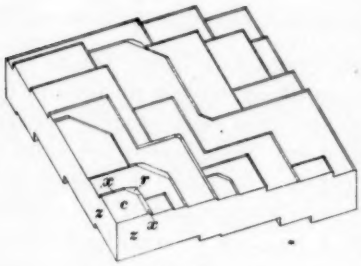

Fig. 1.

Optical properties. Because of the good cleavages most of the attempts to grind oriented sections of the small crystals failed. Only one thick slice approximately parallel to (010) was obtained. The optical properties have therefore been studied chiefly on fine powder or small cleavage pieces under the microscope. The results are accordingly incomplete and only of approximate accuracy.

The refractive indices were determined by the immersion method in sodium light with the following results: $\gamma_{Na} = 1.615 \pm 0.003$; $\beta_{Na} = 1.604 \pm 0.003$; $\alpha_{Na} = 1.602 \pm 0.003$.

According to these determinations the maximum birefringence is: $\gamma - \alpha = 0.013 \pm 0.005$ The optical character is positive. The axial angle was determined under the microscope on small grains showing both axes near the center of the field. Average of 4 determination of reasonable sharpness gave $2V = 20\frac{1}{2}°$ ($2E = 33°$). The optical orientation is the following: $Bx_a = \gamma$ approximately parallel to a-axis. β parallel to b-axis. $Bx_o = \alpha$ forming approximately 15° with c-axis in obtuse angle (i.e., being nearly perpendicular to c (001).

[2] G. W. Clarke (Amer. Journ. Sci. III. **14**: 281. 1877) gives G = 2.598 (22°) and 2.559 (18°). These values, however, can not refer to the crystallized substance, but may represent the density of the amorphous powder.

TABLE 1

ANGLES MEASURED ON CRYSTALS OF MAGNESIUM PYROPHOSPHATE

	(001):(110)	(001):(1$\bar{1}$0)	(001):($\bar{1}$01)	(110):(1$\bar{1}$0)	(001):($\bar{1}$12)
	77° 53′	78° 3′	64° 0′	75° 5′	45° 10′
	78° 8′	77° 56′	64° 21′	74° 59′	45° 22′
	78° 4′	78° 3′	64° 14′	74° 56′	
			64° 7′	74° 59′	
			64° 21′	74° 50′	
			63° 56′	74° 59′	
			63° 45′		
			64° 7′		
			64° 3′		
			64° 6′		
Mean.....	78° 1′.5	78° 0′.5	64° 6′	74° 58′	45° 16′
Average.....	*78° 1′		*64° 6′	*74° 58′	
Calculated.....	(001): (112) = 45° 21′				

* Angles used in calculation of axial ratios.

The plane of symmetry (010) is accordingly the plane of the optic axes. As the acute bisectrix γ is nearly parallel to (001) and the obtuse axial angle is very large, basal sections show no axial interference figures when examined in convergent light. Sections parallel to (010) extinguish nearly parallel to the cleavage lines of (001) and at an angle of about 15° with the *c*-axis (i.e., cleavage lines of (110).

MANGANESE PYROPHOSPHATE

The manganese pyrophosphate ($Mn_2P_2O_7$) forms small prismatic crystals composed of a great number of thin prisms in parallel intergrowth. The crystals are monoclinic and, as far as the measurements go, show very nearly the same crystallographic properties as the magnesium pyrophosphate. Only two independent angles could be measured, however, and the complete axial ratios could not be established. The following incomplete axial ratios were calculated: $a : b : c = 0.7834 : 1 : ?$; $\beta = 74°9'$.

The forms *c* (001); *a* (100), and *z* (110) were observed on 4 measured crystals. The angles are given in Table 2.

TABLE 2

ANGLES MEASURED ON CRYSTALS OF MANGANESE PYROPHOSPHATE

	(001):(110)	(001):(1$\bar{1}$0)	(110):(1$\bar{1}$0)	(100):(110)
	79° 49′	79° 49′	74° 2′	37° 16′
	79° 58′	79° 52′	73° 59′	37° 12′
	79° 56′	79° 48′	74° 2′	36° 50′
	79° 50′	79° 53′		
	79° 53′	79° 50′.5		37° 6′
Average	*79° 51′		*74° 1′	
Calculated angle	(100): (110) = 37° 0′.5			

* Angles used in calculation of axial ratios.

Figure 2 shows the general appearance of a complex crystal. The prism *z* is always the prevailing form. The small faces of *c* terminate the narrow prisms. The pinacoid *a* only occurs as very narrow truncations of some of the edges *z* : *z*. The faces were all bright, especially *z*, which was observed both as crystal faces and cleavage faces and gave good signals.

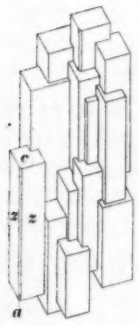

Fig. 2.

The color of the crystals is brownish pink; the powder is light pink. The luster is glassy. Hardness about 4. Cleavage perfect along the prism *z* and poor parallel to *c*. The density determined with pycnometer is $G(\frac{25}{4}) = 3.707$.[3]

Optical properties. Cleavage pieces and fine powder only were examined under the microscope. No material for more elaborate examination was available. The refractive indices for sodium light were determined by the immersion method $\gamma_{Na} = 1.710 \pm 0.003$; $\beta_{Na} = 1.704 \pm 0.003$; $\alpha_{Na} = 1.695 \pm 0.003$ from which the birefringence $\gamma - \alpha = 0.015 \pm 0.005$ is deduced.

The optical character is determined as positive.[4] The axial

[3] G. W. Clarke (Amer. Journ. Sci. III. **14**: 281. 1877) states G = 3.5847 (20° and 3.5742 (26°). These low values may be due to impurities.

[4] From the determinations of the refractive indices giving $\gamma-\beta<\beta-\alpha$ a negative optical character should be inferred. It is however plainly seen that a variation of the indices within the limits of error may change their relation so as to make the optical character positive.

angle is, however, so large that most of the grains observed under the microscope allow no conclusion whatever as to the optical character, the dark bar being apparently straight. Only a few favorable grains rendered the determination certain, these grains showing a bar with a slight though distinct curvature.

Attempts to determine the axial angle under the microscope failed on account of the difficulty in finding grains with proper orientation. Owing to the good cleavage most of the grains were oriented along a cleavage face not showing any optic axis, and in the few cases of an optic axis appearing in the field it was in a position not favorable for satisfactory measurements (e.g., too near the center of the field). It may, however, be concluded from the curvature of the dark bar that the axial angle is not much less than 90°. A probable estimation is 2V = about 80°. The optical orientation is as follows: $Bx_a = \gamma$ forming approximately 20° with a-axis in obtuse angle β; β parallel to b-axis. $Bx_o = \alpha$ forming approximately 4° with c-axis in acute angle β. The plane of symmetry is thus the plane of optic axes and sections parallel to this plane have an extinction angle of about 4° in acute angle β against cleavage lines.

Thick cleavage pieces show faint pleochroism: α light pink; β, γ nearly colorless with a faint yellowish tinge.

A comparison of the properties of the two compounds described in the preceding pages shows that they are isomorphous; a comparison with other crystals proves that they belong to a new group of isomorphous substances not hitherto described.[5] As to the crystallography of the other members of this group (probably the pyrophosphates of different bivalent metals) nothing is known.

The isomorphism[6] of the two compounds is here established on the basis of similarity of chemical constitution, crystal form

[5] The only anhydrous pyrophosphate whose crystallographic properties are known, the Thallopyrophosphate $Tl_4P_2O_7$ has an entirely different axial ratio. Lamy and Des Cloizeaux, Ann. Chim. Phys. (4) **17**: 325. 1869. See Groth's Chem. Cryst.

[6] For an exhaustive discussion of the different meanings of the term isomorphism see Hlawatsch, Zs. Kryst. **51**: 417. 1912.

and structure as revealed by the chemical formula, the axial ratios and the properties of cohesion (cleavage).

It is seen that the two compounds form monoclinic crystals whose axial ratio $a : b$ and angle β are very nearly of the same magnitude. As to the ratio $b : c$ nothing can be said owing to the lack of a sufficient number of angles in the manganese pyrophosphate crystals. The agreement in internal structure of the crystals is evident from the presence of cleavage along the same faces. Both kinds of crystals have a perfect cleavage along the prism z and in both there is a cleavage parallel to c though not equally good in both. It may also be worth mentioning that there is agreement in other physical properties. The hardness is the same and the specific gravity of the same order of magnitude in the two substances. Altogether it seems on the basis of the chemical composition and the crystallographic properties, entirely justified to rank the two substances together as isomorphous.

Isomorphism is, however, sometimes defined so as to imply miscibility in the solid state (solid solution, mix-crystals). In order to examine whether the two phosphates here considered were isomorphous also in this extended sense a few experiments were carried out:

Three intermediate mixtures containing 75, 50 and 25 per cent $Mn_2P_2O_7$ (and a corresponding amount of $Mg_2P_2O_7$) were prepared. With these mixtures heating curves were run and the substances were examined under the microscope. The results are listed in Table 3, where also the melting points and refractive indices of the pure compounds are given for comparison.

It is plainly seen that there is a gradual transition from one component to the other, both in "melting point"[7] and mean refractive index. The heating curves showed no breaks other than those corresponding to the melting points and the microscopic examination proved that only one solid phase was formed by crystallization of the melts.

[7] The breaks on the heating curves of the mixtures correspond to points between the liquidus and the solidus. In the present case these points probably fall very near the liquidus. This may be inferred from the sharpness of the breaks.

In the mixtures containing 50 and 75 per cent $Mg_2P_2O_7$, some of the crystals showed an undulatory extinction indicating zonal structure. This is what should be expected of crystals formed from melts where perfect equilibrium did not obtain through all the period of crystallization. The lack of equilibrium was evident from the fact that the crystallization of these melts took place with a considerable undercooling. At any rate, the inhomogeneity of the mix-crystals due to zoning is not nearly great enough to arouse suspicion of the separation of two distinct phases. The mixture containing 25 per cent $Mg_2P_2O_7$ shows perfectly homogeneous crystals and the undercooling of the melt is insignificant.

TABLE 3

COMPOSITION		BREAKS ON HEATING CURVE (MELTING POINTS)	MEAN REFRACTIVE INDICES
$Mn_2P_2O_7$	$Mg_2P_2O_7$		
		deg. C.	
100	0	1196	1.70
75	25	1242	1.67
50	50	1286	1.65
25	75	1340	1.63
0	100	1383	1.60

The optical character of all the mix-crystals is positive. The axial angle varies according to composition. It is large in the mix-crysta's containing 75 per cent $Mn_2P_2O_7$; medium in the 50 per cent crystals and small in the 25 per cent crystals.

The facts stated prove conclusively that the two phosphates are perfectly miscible in the solid state and that the system $Mg_2P_2O_7$:$Mn_2P_2O_7$ belongs to Roozeboom's Type I, the type without a maximum or minimum.

BOTANY.—*The name of the wood-apple, Feronia Limonia.* WALTER T. SWINGLE, Bureau of Plant Industry.

The wood-apple of India, Ceylon, and Farther India is a deciduous tree with odd-pinnate leaves and globose fruits about the size of an orange, with a hard, woody rind. It belongs to the orange subfamily, Citratae, of the Rutaceae and is one of the

typical hard-shelled citrous fruits, a group including the genera Feroniella, Aegle, Chaetospermum, Balsamocitrus, and Aeglopsis, with a range from Indo-China and the Philippine Islands to West Africa.

The wood-apple was first given a binomial name by Linnaeus in 1753 as *Schinus Limonia* (Sp. Pl. **1**:389), with citation to a rather full description drawn up by Linnaeus himself and published, in 1747, in his account of Hermann's herbarium of Ceylonese plants (Fl. Zeyl., pp. 77, 78, No. 175). Hermann's herbarium, now in the Botanical Department of the British Museum, shows that the specimens studied by Linnaeus and labeled by his own hand consist of two sterile twigs of the wood-apple. In addition to this material there are in Linnaeus' own herbarium two twigs with flowers and loose leaves of this plant, labeled "Limonia" in Linnaeus' handwriting. It is clear that Linnaeus studied both flowers and foliage from his description in Flora Zeylanica which he concludes as follows: "Ex flore & facie ad hoc genus plantam retuli."

Now, Linnaeus attempted to collate in his Flora Zeylanica what had been published previously on tropical and especially East Indian botany and in this case added references to some seven previously published descriptions which he considered to be synonymous but which represent three or four distinct species belonging to as many genera. Two plates are cited, one in Rumphius (Herb. Amboin. **2**: 134, *pl. 43*) representing a branch of the wood-apple with flowers and young fruit, and one in Rheede (Hortus Malabaricus **4**: 31, *pl. 14*) representing a branch with flowers and mature fruits (also a section of fruit and seeds) of quite a different plant, *Hesperethusa crenulata* (Roxb.) Roemer, commonly but erroneously called *Limonia acidissima* L.

The type of *Schinus Limonia* L. is certainly the plant described by Linnaeus in his Flora Zeylanica, the wood-apple, notwithstanding the citation of quite different species of previous authors as synonyms. This is shown unmistakably not only by the type specimens in the Hermann and Linnaean herbaria but also by Linnaeus' description in Flora Zeylanica (p. 78) which says: "foliola . . . . *emarginata*" which phrase cannot possibly

apply to any of the other plants of which descriptions are cited by Linneaus in the synonomy. This fact was first pointed out by Trimen,[1] in 1887, on the basis of the specimens preserved in Hermann's herbarium. Apparently he did not know of the existence of the flowering specimen in Linnæus' own herbarium.

In 1762, Linnaeus, in the first volume of the second edition of his Species Plantarum, abandons the name *Schinus Limonia*, restricting the genus Schinus to the Peruvian pepper trees and creating a new genus, Limonia, for the wood-apple which he calls *Limonia acidissima*. He does not cite the *Schinus Limonia* of the first edition of Species Plantarum as a synonym, but his use of the former specific name as the generic name and the reference to his previous description in Flora Zeylanica make it clear that *Limonia acidissima* L. is merely another name for *Schinus Limonia* L. The original specific name could not be retained without forming a duplicate binomial, a barbarism which Linnaeus never countenanced.

Four citations are given under *Limonia acidissima*. The first is to Burman's Thesaurus Zeylanicus, p. 143, which includes two or more species, one of them being very probably the common lime *Citrus aurantifolia* (Christm.) Swing. The second citation is to his own Flora Zeylanica, p. 77, 78, and certainly applies to the wood-apple. The third citation is to Rumphius Herbarium Amboinense, vol. 2, *pl. 43*, which is also the wood-apple or a closely allied species. The fourth citation is to Rheede, Hortus Malabaricus, Pt. 4, *pl. 14*, and is *Hesperethusa crenulata* (Roxb.) Roem.

Linnaeus thus confused several very distinct plants under his *Limonia acidissima*. Unfortunately, practically all post-Linnaean authors apply this name to a small-fruited Indian tree, *Hesperethusa crenulata* (Roxb.) Roem., while the wood-apple is commonly called *Feronia elephantum* Corrêa.

Fortunately, the confusion that would be caused by changing the current application of the name Limonia and applying it to the wood-apple can be avoided, because the name Limonia proves to

[1] Trimen, H. Hermann's Ceylon Herbarium and Linnaeus's "Flora Zeylanica," in Journ. Linn. Soc. Bot., **24**: 142 (n. 160, 28 Nov. 1887).

be invalid, being a mere variant of Limonium. Linnaeus in the 1754 edition of Genera Plantarum, (ed. 5, p. 135) reduced the latter name to a synonym of Statice, and consequently this name or any variant of it cannot be revived for any plant not congeneric with the type of the original Limonium.[2] As a matter of fact, Limonium has recently been resuscitated in its original sense and is now so used by many taxonomists.

Even if we assume that Linnaeus with his well-known aversion to barbarous names[3] had latinized the name Limon, the usual pre-Linnaean name of the lemon, we would still be forced to conclude that he had brought it into a correct Latin form, just as he did in changing Anona, derived from an aboriginal American name, to Annona, a classical Latin word.[4] This would mean that he had transferred Pliny's Latin name Limonia[5] to a quite different plant, the East Indian wood-apple, in accordance with a reprehensible practice often followed by him. In this case, the Latin name Limonia would still be a mere variant of Limonium, even though derived indirectly from the barbarous word Limon.

Limonia then being invalid, the next oldest generic name must be taken up. This is Feronia, published by Corrêa in 1800, the name now commonly used.

Since the wood-apple was first published as *Schinus Limonia* by Linnaeus in 1753, the oldest valid name of the wood-apple is *Feronia Limonia* (L.) n. comb.

[2] Cook, O. F. Nomenclature of the Sapote and the Sapodilla, in Contrib. U. S. Nat. Herb. **16**: 282 (no. 11, December 13, 1913).

[3] Linnaeus, C. Philosophia Botanica, p. 163, ¶ 229, Stockholm., 1751.

[4] Safford, W. E. The genus Annona: The derivation of its name and its taxonomic subdivisions. This JOURNAL **1**: 118 (n. 4, September 19, 1911).

[5] Limonia and Limonium were both used by Pliny as names of plants and were derived from the Greek λειμωνία and λειμώνιον, the feminine and neuter forms of the adjective λειμώνιος from ὁ λειμών a grassy plain, meadow, prairie. The Greeks used both the feminine and the neuter forms as substantives, ἡ λειμωνία being a kind of anemone, τὸ λειμώνιον a Statice, both plants characteristic of meadows. The feminine and neuter forms of the adjective were so differently accentuated in Greek that there was no danger of confusing the two words when used as substantives. In Latin this difference in accent was lost and confusion rendered possible. It is noteworthy that even in Greek only one of the similarly accented masculine and neuter forms of the adjective (λειμώνιος and λειμώνιον) was used as a noun.

ABSTRACTS

Authors of scientific papers are requested to see that abstracts, preferably prepared and signed by themselves, are forwarded promptly to the editors. Each of the scientific bureaus in Washington has a representative authorized to forward such material to this journal, and abstracts of official publications should be transmitted through the representative of the bureau in which they originate. The abstracts should conform in length and general style to those appearing in this issue.

GEOLOGY.—*Mineral resources of southwestern Oregon.* J. S. DILLER. U. S. Geological Survey Bulletin 546. Pp. 147, 11 plates, 26 figures, maps, sections, and views. 1914.

The rocks of southwestern Oregon, the northern portion of the Klamath Mountains, with a northeast strike toward the Blue Mountains are pre-Devonian, Devonian, Carboniferous, Jurassic, Cretaceous, and Eocene to Pleistocene inclusive. Paleozoic and Mesozoic lavas and intrusives, including greenstones, serpentines, granodiorites, and a variety of dike rocks cut the crushed sediments. The fissuring was general instead of being concentrated in narrow belts. The final veining of the rocks and the accompanying ore deposition formed many small though commonly rich ore bodies instead of a few large ones.

The deep weathering of the rocks during the late Mesozoic and Tertiary concentrated the heavier metals in the residual mantles that gave much to the auriferous gravels of (1) the invading Cretaceous sea (beaches) encircling the Klamath Mountains, (2) the enlivened streams of the Klamath Peneplain, (3) streams of the Sherwood Peneplain, and (4) streams of today. Under favoring conditions the deep weathering of the later geologic periods may have contributed to the secondary enrichment of the "pockety deposits" for which southwestern Oregon is well known.

The overturning of the folded strata and the overthrust of the Devonian upon the Jurassic toward the sea on the northwest is apparently a fundamental structural feature of the Klamath Mountains. J. S. D.

PALEONTOLOGY.—*The Upper Cretaceous and Eocene floras of South Carolina and Georgia.* EDWARD W. BERRY. U. S. Geological Survey Professional Paper 84 Pp. 200, with maps, sections, and 29 plates. 1914.

Upper Cretaceous plants are found in the Middendorf arkose member of the Black Creek formation in South Carolina. This member represents the initial phase of littoral and perhaps partly continental deposits after the widespread interval that succeeded the Lower Cretaceous. The flora contains 76 species in 49 genera, 36 families, and 26 orders and is believed to indicate conditions comparable with those existing in the warm temperate rain-forests of the present. The flora is part of an association that extends from Texas throughout the Atlantic coastal plain, reappearing in the Atane beds of western Greenland. It is shown to have been contemporaneous with the deposition of the upper Tuscaloosa formation of the eastern Gulf area and with the Magothy formation of the northern Atlantic coastal plain and with a part of the Turonian stage of European geology.

A somewhat similar but in part younger fossil flora is described from the Eutaw and the basal beds of the Ripley formation in western Georgia. The deposits range from littoral to marine and yield a total flora of 32 determinable species which indicate conditions essentially similar to those mentioned for the Middendorf flora.

A small but highly interesting flora is described from the Congaree clays of eastern Georgia. These are of middle Eocene age and are known officially as the Congaree clay member of the McBean formation of the Claiborne Group. The plants indicate that the deposits are to be correlated with the Lutetian stage of the Paris basin. The flora contains swamp ferns (Acrostichum) of tropical affinities and several types of plants of modern mangrove associations, as well as palms and numerous coastal types. It is fittingly compared with the existing costal floras of southern peninsular Florida and Central America and furnishes exceedingly important data for phylogenetic speculations, as well as for the elucidation of the climatic and geologic history of the Mississippi embayment area. E. W. B.

MAMMALOGY.—*Treeshrews: An account of the mammalian family Tupaiidae.* MARCUS WARD LYON, JR. Proceedings of the U. S. National Museum **45**: 1–188, pls. 1–11, text figs. 1–15. November 29, 1913.

This extensive monograph of the insectivorous mammals included in the family Tupaiidae is based on an examination of about 800 specimens,

a great part of all the material preserved in the museums of the world. The U. S. National Museum alone furnished 324 specimens, including 29 types, almost all of which were collected and presented by Dr. W. L. Abbott.

The treeshrews are here divided into two subfamilies, one containing the treeshrews proper, 5 genera, and the other only the aberrant pentail (Ptilocercus), with two subspecies. The generic names Anathana for the Indian species and Tana for the long-snouted Malay forms are new. In the restricted typical genus Tupaia there are 48 forms, 5 of which are new; in Anathana 3, 2 of which are new; in Tana 12, 6 new; and in the Philippine Urogale only a single species. The remarkable pentail shrew (Ptilocercus), though described in 1848, is still so rare in collections that only twelve specimens are known to the author.

In addition to the systematic account of the genera and species, the paper includes a history of the animals, their discovery, systematic history, geographical distribution, and habits. The osteology and visceral anatomy are described at length. Details of the skull and teeth of each genus are illustrated by text figures, and the external appearance, the skeleton, and skulls of groups of species are shown on plates. The geographical distribution of each form is shown by maps, and there are extensive tables of measurements of specimens. N. HOLLISTER.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE CHEMICAL SOCIETY

The 239th meeting was held jointly with the Baltimore Branch, on May 2, 1914, at Johns Hopkins University. Dr. PENNIMAN of the Maryland Board of Health exhibited a vacuum regulator for distillation in vacuo. Discussed by Acree, Bunzel, Sosman, and others.

The following papers were read:

W. W. RANDALL, of the Maryland Board of Health: *The determination of camphor in spirits of camphor.* The method depends upon the salting out of the camphor by concentrated solution of calcium chloride, followed by its solution in a measured volume of gasoline, and measurement of the volume of the resulting solution. The dissolving of camphor in gasoline is not accompanied by any change in total volume. Discussed by Engelhard, Penniman, Caspari and Acree.

J. H. SHRADER of the Gibbs Preserving Company: *The reactions of propyliodide with both the ions and the molecules of sodium phenolate.* Discussed by Bunzel, Acree, Sosman, Phelps.

F. M. BOYLES, *Secretary Baltimore Branch.*

The 240th meeting was held at the Cosmos Club, May 14, 1914, at 8:15 p.m. The following papers were read: R. C. WELLS, of the Geological Survey, *The electromotive behavior of soluble sulfides.* The speaker measured the potential of the sulfur ion in concentrations ranging from 10^{-23} N to 0.09 N and worked out mathematical relationships correlating the values obtained. The agreement between the calculated and observed values for E is very good. The divalent sulfur ion is far more reducing than even the iodine ion. The electromotive force measurements do not show the existence of disulfides and trisulfides in polysulfides.

Discussion. Acree inquired about the constancy of the values obtained with the calomel electrode. It was stated that the experiments were only made with an accuracy of 0.01 volt, so that the small fluctuation of the calomel electrode could be overlooked. The calomel electrode is much more constant than the sulfur electrode.

S. F. ACREE, of Johns Hopkins University: *The reactions of both ions and molecules of acids, bases and salts.* The speaker studied about 30 reactions experimentally and as many more from the data of others, and calculated separately the velocity constants of the reactions due to the molecules and those due to the ions. This was done with widely varying concentrations and at different temperatures. In all cases both ions and molecules were shown to enter into the reaction.

H. H. BUNZEL, *Acting Secretary.*

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 738th meeting was held on March 14, 1914, at the Cosmos Club, President FISCHER in the chair; 60 persons present.

The evening was devoted to a symposium on photography. Mr. E. D. TILLYER spoke on *Photographic lenses and plates.* He discussed the old and new types of glass used for lenses and described briefly the methods of correcting for spherical aberration, coma, astigmatism, curvature of field, distorsion, and chromatic aberration. Various types and combinations of photographic lenses were illustrated by lantern slides. Requirements of plates for different purposes as regards emulsion, rapidity, and grain were discussed. Paper was discussed by Mr. HUMPHREYS.

Mr. K. BURNS spoke on *Astronomical photography and the Schumann region.* The Schumann region is so-called because before his investigations observations could not be made in regions where wave lengths are less than 1800 Ångström units. For astronomical use plates must usually be rapid at low intensities. The application of refractors and reflectors to astronomical photography was discussed at length and lantern slides shown of instruments and photographs of interesting celestial regions. For wide fields the refractor is limited by the coma. The paper was discussed by Messrs. RINES and HUMPHREYS, particularly as to photographs giving details of planetary surface markings.

Mr. F. E. WRIGHT presented a paper on *Color photography* and illustrated his paper by some excellent specimens of this work. Color photography is based on Helmholz's trichromatic theory. Present practical methods are three: By taking three exposures simultaneously through three films, one red, one blue, and one green, and superimposing the three negatives by use of prisms; by use of screen ruled alternately with red, green, and blue lines about $\frac{1}{200}$ inch apart; and Lumière's method by use of very small starch grains dyed red, green, and blue and mixed together and mounted on back of sensitized plate, the back being placed next the lens when photograph is taken. The slides exhibited were taken by the second method. The paper was discussed by Messrs. BAUER, PRIEST, TILLYER, and HUMPHREYS. At 10:05 the meeting adjourned.

The 739th meeting was held on March 28, 1914, at the Cosmos Club, President FISCHER in the chair; 36 persons present.

Mr. R. Y. FERNER presented a paper on *A reasonable performance of a high grade watch.* He outlined the methods of tests used in four prominent foreign observatories and gave the criterions and tolerances by which the performances of watches under test are judged. It was pointed out that for the determination of the true quality of the position adjustment of a watch it is desirable to eliminate, by the method of test, the gradual progressive change of rate which is evident in practically all watches. Lantern slides giving curves of results of isochronism tests were shown, and the desirability of this test pointed out. An outline of the test which will be applied to watches at the Bureau of Standards was then shown, together with the tolerances which have been adopted for the granting of

certificates of the watches' performances. In conclusion, some results of pocket tests of watches made by Mr. F. M. BOOKWALTER were shown and the principal uses and value of a laboratory test in later use and care of one's watch pointed out. The paper was discussed by Messrs. BOWIE, FISCHER, and WELLS.

Mr. W. P. WHITE then spoke on *Calorimeter jacket design*. The two difficult features of calorimetric work are temperature measurement and cooling rate determination. The more nearly the cooling rate is proportional to change in temperature, the better is the result. The general conclusion was reached that cooling rate has not so much to do with distance between two surfaces of calorimeter as with shape of cavity. The paper was discussed by Mr. DICKINSON.

Mr. W. BOWIE communicated informally the initiation by the Canadian government of an extended gravity survey of Canada. He also stated that the Coast and Geodetic Survey has found that Western Union noon time signals may be relied upon to 0.1; this means that cost of gravity work may be much reduced, there being no further need of field time observations. At 10 p.m. the meeting adjourned.

The 740th meeting was held on April 11, 1914, at the Cosmos Club, Vice-President EICHELBERGER in the chair; 42 persons present.

Mr. W. D. LAMBERT presented a paper entitled *The motion of falling bodies*. The author discussed the effect of the Earth's rotation on the motion of a body falling from rest and particularly as regards the component of the motion parallel to the plane of the meridian. The problem was treated in two ways, first by considering the falling body as a satellite of the Earth and, second, by the method of moving axes. The first method is not limited to short intervals of time but neglects the effects of the Earth's equatorial protuberance. If the displacement parallel to the plane of the meridian be expanded in powers of time, t, and terms involving powers of ω higher than ω^2 be neglected, ω being the angular velocity of the Earth's rotation, then there is no term in the expansion with a power of t lower than the sixth. The second method may be arranged to take account of the Earth's ellipsoidal form, the changes in the direction of gravity being allowed for in successive approximations. The second method verifies result of the first as to term in ω and brings out a very small southerly deviation (reckoned from the direction of gravity at the starting point) due to the ellipsoidal form of the Earth. The result may be analyzed in the following manner, speaking for the northern hemisphere: The direction of gravity changes during the fall of the body, first from the change in centrifugal force, which tends to give a northerly deflection; second, from the change in attraction of the equatorial protuberance, which tends to give a southerly deflection. There is, however, also a relatively large easterly deflection, and the velocity with which this takes place gives rise to an apparent force due to the Earth's rotation and tending to swing the easterly deviation to the right (northward); this is just sufficient to neutralize that arising from change in centrifugal force and leaves outstanding that due to Earth's equatorial protuberance.

The paper was discussed at some length by Mr. WOODWARD, particularly as regards the surface of reference, and by Messrs. BOWIE, GRAY, and BUCKINGHAM.

Mr. BOWIE made a brief informal communication showing evidence of nearly perfect isostasy in India from reductions at 14 gravity stations.

The usual hour of adjournment being at hand, it was moved and carried to extend the time to permit the reading of the second paper of the evening by Mr. W. J. HUMPHREYS *On thunderstorms*. The author discussed the mechanism of storms and applied in this connection the conclusion from W. Simpson's work in India that electricity with rain is essentially positive. The paper was illustrated by lantern slides showing, among other things, in particular the barometric conditions accompanying different types of storms. At 10:50 p.m. the meeting adjourned.

The 741st meeting was held on May 9, 1914, at the Cosmos Club, President FISCHER in the chair; 30 persons present.

Mr. L. W. AUSTIN spoke on *Recent experiments in the reception of radiotelegraphic signals*. The greatest obstacle not yet overcome in wireless signaling is the presence of atmospheric disturbances which confuse and often drown out signals being received; this difficulty is becoming greater as the receiving apparatus is becoming more sensitive. The author described methods to do away with this disturbance and in particular recent experiments with tuning spark apparatus. The most recent and interesting development is the improved oscillating audion and ampliphone of De Forest. The paper was discussed by Messrs. WHITE, BOWIE, BAUER, HUMPHREYS, MARVIN and DELLINGER as to automatic receiving apparatus, greater facility of transmission for north-south than east-west direction, latest ideas of causes of atmospheric disturbances, height of path, and amount of energy expended in sending, compared with amount received. Mr. AUSTIN stated there seemed to be no certain evidence as to greater ease of transmission in any particular direction; the disturbances are of local type and those at a distance, as discharges between clouds; there has been no close connection noted between weather and receiving conditions.

Mr. R. A. HARRIS then spoke *On periodic quantities, especially motions*. This communication was concerned with a series or aggregation of periodic terms, or with several such series considered simultaneously. A term of the form $ae^{i(\alpha t+\alpha)}$ is regarded as representing the simplest kind of periodic function because as t increases uniformly the function of t represented will describe a circle about its origin at a uniform rate. When there are several such terms, additional concepts arise, as amplitude ratios, speed differences, relative phases, and quantities in which these concepts are involved. A series of terms having the imaginary exponential form represents epicyclic motion. The simultaneous use of two series of terms where both commensurable and incommensurable speeds occur is exemplified in the new tide-predicting machine. Three series of periodic terms are suitable for space in general. At 10:10 p.m. the meeting adjourned.

The 742d meeting was held on May 23, 1914, at the Cosmos Club, Vice-President BURGESS in the chair; 27 persons present.

Mr. E. BUCKINGHAM presented a paper on *The interpretation of experiments on models.* The speaker began by deducing a general theorem regarding the form which physical equations must have in order to satisfy the requirement of dimensional homogeneity. The theorem may be stated as follows: If a relation subsists among a number of physical quantities, and if we form all the possible independent dimensionless products of powers of these quantities, any equation which describes the relation is reducible to the statement that some unknown function of these dimensionless products, taken as independent arguments, must vanish. The method of determining the number and forms of these products was explained. This theorem may be regarded as a convenient general summary of the requirement of dimensional homogeneity. It may be looked at from various standpoints and utilized for various purposes. The speaker gave several illustrative examples to show the practical operation of the theorem. The paper was discussed by Messrs. HERSEY, WHITE, BURGESS, and HUMPHREYS.

Mr. G. K. BURGESS spoke informally on *The allotropy of iron,* calling attention to recent advances made with particular reference to β-iron. The communication was discussed by Mr. WHITE.

Mr. W. J. HUMPHREYS spoke informally on *Is lightning discharge of direct or oscillatory character?* The speaker concludes that it cannot be oscillatory. The communication was discussed by Messrs. WHITE, AGNEW, and C. A. BRIGGS. At 10 p.m. the meeting adjourned.

J. A. FLEMING, *Secretary.*

THE ANTHROPOLOGICAL SOCIETY OF WASHINGTON

At the 472d regular meeting of the Society held at the National Museum, Tuesday, February 17, 1914, at 4:30 o'clock, Mr. J. N. B. HEWITT gave an address entitled, *The psychology of the myth.* A myth is the utterance of savage man; it is a naive creative concept. A myth treats of one or more of the "elder people," the familiar "first people," whom men of later times call "the gods." The subject-matter of myths is not human activity; for none relate to human beings, and none treat of things done since the appearance of man on earth. A myth is fictitious only in form and letter; but it is true in substance and spirit; truth is eternal, universal.

In terms of human form, attribute and activity, myths explain from the premises of their makers in just what manner the present order of things arose from one or more antecedent orders of things, and just how the present order is maintained.

The epos is the later dress or adornment of the mythos concept in poetic form as legend, saga, or story.

The logos is the still later literary criticism—the analytic and synthetic treatment—of the mythos and the epos; it is the intelligent, interpretative analysis and exegesis of the concept expressed by the mythos; it is

logical, scientific; so mythology may be defined as the logic of the mythos. The first men had only myths; and whether as cosmogony or as religion they were final, conclusive.

Hence, mythos and epos and logos, all translatable as *word*, represent three well-defined stages of human thought in the development of opinions. Whatever, therefore, the ultimate terms or concepts may be in which man may define his gods, the process of his reasoning is always quite the same; the "unknown" is defined, though perhaps, unconsciously, in terms of the "known;" but the "known" quantity here is man, whatever this concept may signify at the time and place.

The phenomena, the bodies and the processes of nature are personified, and so humanized—a process of thought which is called anthropomorphism. So that all powers and functions and attributes characteristic of man—no matter whether good or evil—are ascribed to the gods in a more or less idealized form. Not only this, but the arts of men and the social and religious institutions of men are in like manner unconsciously attributed to the gods; and so the social and the religious institutions of the gods are ever an exact reflex of the human society over which these self-same gods preside.

By so doing, men give, in their myths and epics, though unconsciously perhaps, a faithful picture of the early culture and civilization of their own ancestors. In this manner, in brief, the gods in later times become the revealers of all history, the divine teachers of the arts and the crafts, and the founders of the institutions—human and divine—of a people. Here is found the true source of prophecy and inspiration; for these divine beings are the offspring of the interaction of the powers and the bodies and the phenomena of nature and the mind of man in its three-fold activities—the conscious, the subconscious and the superconscious. (*Author's abstract.*)

A special meeting of the Anthropological Society of Washington was held Tuesday, March 3, 1914, at 4.30 p.m., in the new National Museum Building, the President, Mr. Stetson, in the chair; 37 persons present.

Mr. W. E. SAFFORD, Economic Botanist of the Department of Agriculture, read a paper on *The pan-pipes of ancient Peru.* Several specimens and figures on vases were shown and compared with ancient syrinxes, or fistulas, from Greece and Rome. (See this JOURNAL, **4**: 183–191. April 19, 1914.)

At a special meeting of the Society held March 4, 1914, at the National Museum, Dr. A. B. LEWIS gave an address on his *Travels in the South Seas and New Guinea*, illustrated with excellent lantern slides. The four years of 1909–1913 were spent in the South Pacific in the interest of the Field Museum of Natural History, Chicago, studying the natives and collecting ethnological material. The region chiefly concerned was in Melanesia, which includes the island groups extending northwest from Fiji and New Caledonia through the New Hebrides and Solomon Islands to New Guinea. Many of these islands are large and mountainous,

covered with a dense tropical forest, and only partially explored. Though all are claimed by different European powers, only the smaller islands and the coasts of the larger are under control. The traveler is perfectly safe, however, except in a few regions which are well known. Transportation is the great difficulty, and if one wishes to get away from the few settlements it must be by small launches or sailing craft belonging to the scattered traders and planters, or by native canoes. In one of the last the speaker traveled more than 100 miles, stopping at the native villages, sleeping in the native huts, with only natives as attendants and guides.

The condition at present varies much in the different islands; Fiji is the most civilized. The natives of Fiji are all professing Christians and read and write their own language. Excepting the ordinary things of everyday life, there is little of the old left. The native Fijian population is about 90,000 and the European 3,500, while there are 40,000 to 50,000 Indian coolies on the sugar plantations. Industrially, Fiji is far in advance of any of the other groups. New Caledonia was for years a French penal colony, and the natives are reduced to about 30,000 living on reservations, much as our American Indians. The New Hebrides are under the joint rule of France and England, but some of the large islands are still wild and unsafe. To the ethnologist, Malekula is the most interesting. Over twenty languages are spoken on this one island, to say nothing of dialects. The natives, houses, and dancing grounds, with huge carved drums and wooden figures, were illustrated by views. The Solomon Islands are mostly English, but two are under Germany. Including missionaries, there are probably not over three hundred Europeans in the group. Some of the islands still are unsafe, even to land on the shore, except where there is a mission station or government post. New Guinea is the largest and most interesting island of all. Except Greenland, it is the largest in the world, and the least known; for while even Greenland has been crossed several times, New Guinea has never been crossed except near the ends, where quite narrow. More time was spent on New Guinea than anywhere else. A considerable portion of the coast was visited and short trips were made toward the interior. There are but few Europeans in New Guinea, the greater number (about 1000) being in the British portion of the island, known officially as Papua. A considerable number of these are gold diggers. In German New Guinea (Kaiser-Wilhelmsland) there are about 200 Europeans, and in the Dutch portion not over 50. The old condition of warfare among the natives has been stopped as far as the government can extend its influence. The natives, as a rule, are friendly and hospitable. Many weeks were spent alone with them in their villages, with only native attendants. The habits, customs, and general appearance of the natives, while similar in general aspects, vary greatly in detail. Views illustrating the native villages, the people themselves with their characteristic dress and ornaments, and phases of native life, were shown from a number of different places, so that a general idea of their character and variety could be obtained.

At the 473d regular meeting of the Society, held March 17, at the National Museum, DR. J. WALTER FEWKES delivered an address, illustrated with lantern slides, on his *Egyptian experiences*. He considered especially the significance of certain parallelisms in cultural objects of the Stone Age of Egypt and the Gila Valley, Arizona. These resemblances he ascribed in part to the influence of an artificial system of irrigation in the evolution of an agricultural stage in development.

Dr. Fewkes began with an account of the unique shape and cultural isolation of the Nile Valley in Neolithic times and showed how man was isolated by deserts which protected him from outside marauders. His social advancement at the dawn of history, mainly due to the influx of foreign ideas from the East, can be traced to the coöperation between clusters of villages or nomes, this union having been effected in order to irrigate more effectually the narrow valley of the Nile. The coöperation of the rulers of Neolithic Egypt led to a ruler over all, a Great House, or Pharaoh, who later became King of Upper and Lower Egypt. To this coöperation in constructing irrigation ditches may be traced a system of enforced labor or corvée in which the Pharaoh not only acquired all cultivated land, and the water which alone made agriculture possible, but also controlled all labor of the inhabitants. To these rights acquired from the rulers of the nomes in very early times may be traced the powers exercised in constructing the magnificent monuments that are the world's wonders.

In Neolithic Egypt, there was a succession of villages strung along the river, each independent of the other, like a cluster of pueblos in Arizona. The remains of architectural constructions at this early epoch still remain and are sometimes, as at El Kab, well preserved. They are rectangular, massive, walled forts with an encircling wall of clay not unlike the compounds at Casa Grande and the Great Houses elsewhere on the Gila. Within these enclosures in Egypt and Arizona were mud or clay built temples, public buildings, and houses of priests, while around them were clusters of rude hovels in which lived the people like the present Egyptians.

The dead were buried in neighboring mounds, placed with the knees drawn to the chin and surrounded by mortuary offerings. These graves were rude excavations with floor of straw and roof of mud and boughs. Many resemblances between archæological objects from the Stone Age in Egypt and the Gila Valley were pointed out. Among these are weapons, stone implements, pottery and its symbolic decorations, flat basket trays, bone and other specimens.

Certain common conditions of environment and the necessity for artificial irrigation had led the Stone Age people of different races without connections, to develop a parallel culture.

At a special meeting of the Society held March 24 at the National Museum, DR. ALBERT HALE, of the Pan-American Union, addressed the Society on *Modern Argentina*, illustrating his remarks with lantern slides.

After a description of the geographic relations of the Río de la Plata region, with an outline of its ethnical and anthropological conditions, the speaker traced the history of Argentina only so far as it had an immediate bearing upon material progress, and then gave a comprehensive survey of the republic as at present,—its principal cities, its industries, its products, and its activities. One of the interesting features about the republic is that in it is repeated a development quite comparable to that which has been so characteristic of the United States in North America. In fact, this immense area in South America is the one most easily understood by the Anglo-Saxon who looks back upon the history of material progress and conquest in his own country.

The ethnical elements of the population may be studied in the immigration statistics of Argentina more satisfactorily than in its census. In fact, no census has been taken since 1895, when the total population was 3,954,911. In 1911 it was estimated to be over 7,000,000. The total number of immigrants arriving in the years 1857–1912 was 4,248,-355. It is interesting to note that more than half this number, or 2,133,-508, were Italians. The Spaniards were scarcely more than half as numerous as the Italians, or 1,298,122. Other European races were represented by much smaller numbers than these. The French numbered only 206,912 and the "Russians" 136,659. Next to these came a race from Western Asia, the Syrians, with a total of 109,234; then the "Austrians" and "Germans" with 80,736 and 55,068, respectively. The "Britons" numbered nearly as many as the "Germans," or 51,660. The Swiss, Belgians, and Portuguese numbered about 20,000 or 30,000 each; the Danes and Dutch 7000 each; the "North Americans" 5500; the Swedes 1700, and "others" 79,251.

The relative proportions of Italians and Spaniards arriving during the last year of this period, 1912, were about the same as during the entire period, or 165,662 of the former to 80,583 of the latter. It is worthy of note that the "Russians" and Syrians rose to the next two places in the list, with a total for the year of about 20,000 each. No doubt the "Russians" and "Austrians" in Argentina, as in the United States, are largely Poles and Slavs of other races than the true Russian, together with a certain proportion of Hebrews. The "North Americans" arriving during 1912 numbered about 500. The total immigration for the year was 323,403.

A high tide of immigration reached Argentina at about the same period as the United States, in the decade 1881–1890, when a grand total of 846,568 immigrants arrived in Argentina. This number was, however, exceeded in the last half-decade, 1906–1910, when 1,238,073 arrived in Argentina, or a larger proportion than came to the United States during that period.

At a special meeting of the Society, held April 7, at the National Museum, Señor F. A. Pezet, Minister of Peru, read a paper on *Contrasts in the development of nationality in Latin and Anglo-America.* Each of these populations, he said, has its special traits of charac-

ter, born with the individual or developed through the environment. He first considered the relative conditions, at the time of the discovery, of the territories now known as the United States and Latin America; and, second, the type of the first settlers. The discoverers found Latin-American territories organized into semi-civilized states but Anglo-American territory occupied by savages. Two very different types came to America. The Anglo-Americans were oppressed and persecuted by religious intolerance; the Latin Americans were adventurous soldiers of fortune. The former came to build up new homes; the latter, to tear down, to destroy, and to carry away everything they could lay their hands upon. The first Latin Americans were valiant, but ignorant and unscrupulous, principally from a country where religious bigotry was rampant. They were an admixture of virtues and vices and in marked contrast to the men who came to the shores of New England. Whereas the Anglo-Americans acquired the land as settlers and drove the natives westward, the Latin-American military forces overthrew native governments and established themselves as the governing class, reducing the Indians often to slavery.

While the Anglo-American settlers brought their families, the Latin Americans did not until many years after the Conquest, but took to themselves Indian women. The offspring became the "mestizos," a mixed race that the pure Castilians of Spain never countenanced. Later the creoles came into existence, the offspring of European parents born in America. The mixing of races was finally encouraged by the Spanish monarchy, the idea being to create a great middle class of uniform race. Soldiers were allowed a great amount of liberty. Before 1800 A.D. the mestizo population of Peru exceeded 250,000. While some mestizos received an education and were brought up with creole children, most were kept in ignorance. While Anglo-Americans readily acquired the art of self-government, the Latin-American peoples did not; they knew how to rule, not how to govern. So, for more than two centuries, the Europeans and the creoles ruled the mestizos and the Indians. The mestizo is nearer the Caucasian than the Indian; physically and morally he is superior to the Indian. Although of less active intelligence than the European or the creole, he is more strong-willed and painstaking. In the early days the mestizo who had one parent of rank was placed on an equal footing with the creole; but as the mestizos became more numerous, the Spaniards began to distrust them and prevented them from obtaining certain social positions or much education. All these years the Indians were oppressed, even by the mestizos. After two hundred years of hatred and distrust these elements eventually, out of sheer exhaustion, became apparently reconciled to their respective conditions. The colonial nationality, which was finally evolved, was thus formed of creoles and mestizos and might have been a beneficent one if it had had time to develop. Ideas of republicanism were adopted from the United States and from France without preparation for self-government, such as the people of the United States had. In the later nationality of the Latin-American countries there were, therefore, racial

divisions: The creoles and the Spaniards formed the governing class; the mestizos strove to be on an equal footing with these; and, a long way down in the social scale, came the Indians, considered inferior even to the African slaves. The same laxity permitted the mixing of the African with the other races. The Indian population, so long neglected, is now a matter of deep concern in many of the Latin-American countries; for example, in Peru, where there is a larger percentage of pure Indian and of mestizo blood.

At a special meeting of the Society, held April 14 at the National Museum, Mr. S. M. GRONBERGER read a paper on *The origin of the Goths*. The ancient home of the Goths was undoubtedly situated, he said, on both the northern and southern shores of the Baltic, and at the beginning of the Christian era this people had settled chiefly along the river Vistula in northeastern Germany. Previous to the Christian era, another division of this race had immigrated into Scandinavia (about 200–300 B.C.) probably across the Danish isles. Somewhat later, at the time of the earliest Gothic movement southward, about 215 A.D., the migrants were probably joined by their Scandinavian brethren who emigrated from "Scandza" (mentioned by Jordanes, the Gothic historian), and to this period the Gothic saga of Jordanes should be assigned. This emigration of the Goths from Scandinavia was probably due to some signal defeat in the savage warfare then carried on by them with the Swedes or "Svear" of the Scandinavian peninsula. Names of regions and localities in Scandinavia testify to their association with the Goths, and the names of Ostrogoths, or East Goths, and Visigoths, or West Goths, are recognized in the Sweden of today. Mediaeval Swedish history tells of constant conflicts between the Swedes and Goths, the latter of whom were the more ancient inhabitants. The two races are now merged together and constitute the modern Swedish nation. The Anglo-Saxon poem "Beowulf," by an unknown author, furnishes powerful testimony as to the early home of the Goths in the Scandinavian peninsula and the Danish islands. The Baltic island of Gotland received its name from the Goths, and great numbers of Roman and Byzantine coins and other objects which have been unearthed in that island afford further proof of the Scandinavian migrations. In addition to Jordanes, Cassiodorus, upon whose history that of the first named was based, Tacitus, Procopius, and Paulus Diaconus, not to mention the earliest though doubtful evidence of Pytheas of Massilia (now Marseille), who had the advantage of having personally visited the regions he described, testified to the Scandinavian or Baltic origin of the Goths. The most ancient tradition relating to the Goths was that they had come originally from Asia, the cradle of mankind, by way of southeastern Europe under the leadership of their legendary hero and deity, Odin, or Wothan.

One of the most remarkable runic inscriptions in Scandinavia is that of the so-called Rök stone, located in western Ostrogothia, Sweden, which is of great importance in connection with the early history of the

Goths. It contains an epitaph and dates back to 830–840 A.D., or the time of the introduction of Christianity into Scandinavia by St. Ansgar. The inscription contains an allusion to Theodoric the Great, who ruled as Ostrogothic King of Italy. Another part of the inscription refers to four kings of the Danish island of Zealand. The names of these four, who were brothers, and their sons, can be identified with names mentioned in Jordanes' saga. The Rök runic inscription affords one of the most important fragments of historical evidence connecting the Ostrogothic kindgom of Italy with the Goths of Scandinavia, and contains more points of resemblance with Jordanes' saga than any known historic source.

The evidence of relationship between the Gothic and Scandinavian languages, found in the modern Germanic and Scandinavian tongues, is also of great importance. The most essential point of resemblance between these languages is the mutual retention in certain cases of "gg" before "w" and "j" ("ggj" was changed into "ddj" in Gothic); as, for instance, in the genitive plural Old English *tweza* (two), Danish *twaeggie*, Gothic *twaddje*, modern Swedish *twegge*. Compare also the English *true* with Swedish, Danish, and Norwegian *trygg*, Icelandic *tryggr*, Gothic *triggws*.

At the adjourned 474th regular and 35th annual meeting of the Society held at 4 o'clock, May 5, at the National Museum, Dr. EDGAR J. BANKS, field director of an expedition to Babylonia in 1903–1905 under the auspices of the University of Chicago, read a paper, illustrated with lantern slides, on *Bismya; or, the Lost City of Adab.* Bismya flourished in central Babylonia throughout a period of two thousand years previous to 2000 B.C. The mounds extend a mile or more along the bed of an ancient canal, about halfway between the Tigris and Euphrates rivers, and five days' journey south of Bagdad. The highest of the mounds reach about fifty feet above the level of the desert. The surface is covered with pottery fragments. The workmen employed were Arabs of the hostile Bedier tribe. An agreement was entered into with the chief of the tribe to employ workmen only from him, and in return he promised to protect the excavators from the depredations of surrounding tribes. At the head of each gang was a pickman who loosened the dirt and searched through it for antiquities. With him were two scrapers with triangular hoes with which they scraped the dirt into baskets. The scrapers received sixteen cents a day and the basket men twelve, but the pay of each man was doubled for the day on which he found an antiquity of value. Near the surface were found bricks of the temple wall having on their under side the inscription of Dungi, King of Ur, of about 2200 B.C., and below them bricks bearing his father's name, Ur-Engur. At a lower level was found a gold inscription of Naram-Sin and bricks of his father Sargon, the first known Semitic kings, of about 2800 B.C. Until recently the date of these kings was supposed to be about a thousand years earlier.

Beneath the ruins representing these Semitic kings were the traces of the earlier civilization of the Sumerians, a cultured people who had occupied Mesopotamia for several thousand years. From them the wedge-shaped characters of the language and many of the Semitic religious forms were borrowed. An important discovery was a perfect, large marble statue of a Sumerian king called Lugal Da-udu of about four thousand years before the Christian era. Large numbers of stone vase fragments were found; some were inscribed with the names of the kings of the fifth millennium before Christ; others were engraved with intricate designs; and a few of them were inlaid with ivory and bright stones. One bore the picture of the temple power; one had the oldest representation of a musical instrument known to exist. Far down the shaft was discovered a long spike of pure copper terminating in a crouching lion. Lowest down, on the undisturbed desert level, were found large numbers of pottery fragments, showing that perhaps fifteen thousand years ago a people with considerable civilization occupied that spot. An ancient Sumerian crematory was found. It was a circular chamber with an oval platform connected with a furnace. The ashes of the dead were brushed into the pit beneath the platform. The Semite dead were buried in small house-like tombs of sun-dried bricks. In these were found the pottery to contain food and drink for the spirits of the dead, the jewelry of the women, and the seal cylinders of the men. Several palaces were found and in them small collections of clay tablets containing the business documents of the people. In one large chamber were about five thousand of the tablets in a heap. In the residential portion of the city were found the very narrow winding streets lined with houses of but a single room. Many of the houses were provided with vertical drains reaching into the ground forty feet or more, and with cisterns. Frequently there had survived the oven in which the bread was baked, the mortar for pounding the grain, the images of the household gods which were supposed to drive away disease, the toys of the children, the needles and knives of the women, and many other things necessary to life in those days. A public bath was found in the residential section of the city, provided with a vertical drain beneath the floor of bitumen, a furnace for heating the water, and a cistern high up in the building. The people of Bismya were among the oldest who have left us evidences of a highly developed civilization, and the first occupants of the place, ten or fifteen thousand years ago, were as civilized as the present occupants of the surrounding desert.

Mr. James Mooney was elected President of the Society for the ensuing year, and the following officers were re-elected: Vice-President, Dr. John R. Swanton; Secretary, Dr. Daniel Folkmar; Treasurer, Mr. J. N. B. Hewitt; Councilors: Mr. Felix Neumann, Dr. I. M. Casanowicz, and Mr. Francis LaFlesche.

DANIEL FOLKMAR, *Secretary.*

VIRGINIA
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